Severe Weather

Profiling Hazard Event

*Requirement §201.4(c)(2)(i): [The State risk assessment **shall** include an overview of the] location of all natural hazards that may affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate.*

For the purpose of this mitigation plan, the term severe weather is used to represent a broad range of weather phenomena in Utah which include:

- Downbursts
- Lightening
- Heavy snowstorms
- Blizzards
- Avalanches
- Hail
- Tornados

1999 Salt Lake Tornado

Severe weather events are the most deadly type of natural disaster in Utah. More people have died in avalanches in Utah than by any other natural hazard. Between 1958 and 2010 avalanches killed 100 people accounting for 52% of severe weather related deaths. Since 1950 lightening has killed 61 people and injured another 152 people. Lighting deaths accounted for 31 % of severe weather related deaths of weather related deaths.

Downbursts

Downburst - A strong downdraft from a thunderstorm resulting in an outward burst of damaging winds on or near the ground. Downburst winds are often 50 to 100 mph and in a few cases, 100 to 150 mph. They can do as much damage as a small tornado.

- **Microburst** - a small downburst affecting an area less than 2 1/2 miles in diameter with peak winds lasting generally less than five minutes.
- **Macroburst** - a large downburst affecting an area greater than 2 1/2 miles in diameter with peak winds generally lasting five minutes or longer.

Downburst have significant impacts on property. Downbursts events can be deadly; however, no deaths have been attributed directly to downburst events in the State of Utah at this time.

Lightning

During the development of a thunderstorm, the rapidly rising air within the cloud, combined with the movement of the precipitation within the cloud, causes electrical charges to build. Generally, positive charges build up near the top of the cloud, while negative charges build up near the bottom. Normally, the earth's surface has a slight

negative charge. However, as the negative charges build up near the base of the cloud, the ground beneath the cloud and the area surrounding the cloud becomes positively charged. As the cloud moves, these induced positive charges on the ground follow the cloud like a shadow. Lightening is a giant spark of electricity that occurs between the positive and negative charges within the atmosphere or between the atmosphere and the ground. In the initial stages of development, air acts as an insulator between the positive and negative charges. When the potential between the positive and negative charges becomes to great, there is a discharge of electricity that we know as lightning.

Table I-28 Lightning deaths by County from 1950 to March 2010 - Alphabetically .

Cache	2	Morgan	1	Wasatch	2
Carbon	2	Piute	1	Wayne	1
Daggett	1	Rich	1	Weber	2
Davis	1	Salt Lake	8		
Duchesne	5	San Juan	6		
Emery	1	Sanpete	3		
Garfield	4	Summit	7		
Grand	4	Tooele	2		
Iron	1	Uintah	2		
Juab	2	Utah	2	**TOTAL**	**61**

Table I-29 Lightning injuries by county from 1950 to March 2010 in alphabetical order.

Beaver	2	Morgan	2	Wasatch	3
Cache	7	Piute	1	Washington	4
Carbon	5	Salt Lake	42	Wayne	1
Daggett	1	San Juan	3	Weber	4
Davis	3	Sanpete	1		
Duchesne	11	Sevier	3		
Emery	7	Summit	16		
Garfield	6	Tooele	10		
Grand	3	Uintah	3		
Morgan	2	Utah	12	**Total**	**152**

Heavy Snowstorms

A severe winter storm is defined as a storm that deposits four or more inches of snow during a 12-hour period or six inches of snow or more during a 24-hour period. According to the official definition given by the U.S. Weather Service, the winds must exceed 35 miles per hour and the temperature must drop to 20□ F or lower. Winter storms make driving extremely dangerous.

Blizzards

A blizzard is a snowstorm with sustained winds of 40 miles per hour (mph) or more or gusting winds up to at least 50 mph with heavy falling or blowing snow, persisting for one hour or more with temperatures of ten degrees Fahrenheit or colder with potentially life-threatening travel conditions. The definition includes the conditions under which dry snow, which has previously fallen, is whipped into the air and creates a diminution of visual range.

Table I-30 Blizzard and Snowstorms by cost above $150,000
1964 to 2010
(Not corrected for inflation)

HAZARD BEGIN DATE	County	INJURIES	FATALITIES	PROPERTY DAMAGE	REMARKS
2/8/1962	Millard, Sanpete	0	0	$500,000.00	Rain and Snow melt
1/15/1971	Davis, Salt Lake, Weber	0	0	$150,000.00	Fog & Black Ice
1/15/1971	Davis, Salt Lake, Weber	0	0	$150,000.00	Fog & Black Ice
3/21/1973	Box Elder	0	0	$250,000.00	Heavy wet snow
10/18/1984	Salt Lake	20	0	$500,000.00	Snow
12/21/1990	State Wide	5	1	$5,000,000.00	Extreme Cold
1/6/1993	Tooele, Salt Lake, Davis	18	1	$5,000,000.01	Heavy Snow
1/11/1997	State Wide	50	3	$40,000,000.04	Blizzard
3/31/1997	State Wide	30	3	$2,000,000.00	Winter Storm
2/21/1998	State Wide	40	0	$900,000.00	Winter Storm
11/24/2001	State Wide	1		$600,000.00	Winter Storm
1/27/2002	Salt Lake	38	0	$720,000.00	Winter Storm
11/21/2003	State Wide	0	0	$550,000.00	Winter Storm
12/25/2003	State Wide	0	0	$1,500,000.00	Winter Storm
1/1/2006	State Wide	0	0	Amount unknown	Winter Storm

"*Hazards & Vulnerability Research Institute (2011). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org*
**Data reflects Hazard Events until 2009.*

Avalanches

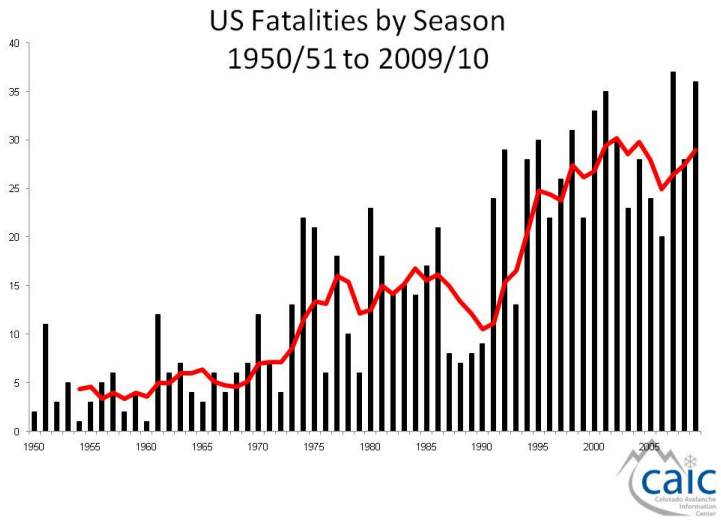
Avalanches are a rapid down-slope movement of snow, ice, and debris. Snow avalanches are a significant mountain hazard in Utah, and nationally account for more deaths each year than earthquakes. Avalanches are the result of snow accumulation on a step slope and can be triggered by ground shaking, sound, or a person. Avalanches consist of a starting zone, a track, and a run-out zone. The starting zone is where the ice or snow breaks loose and starts to slide. The track is the grade or channel down which an avalanche travels. The run-out zone is where an avalanche stops and deposits the snow.

The two main factors affecting avalanche activity include weather and terrain, large frequent storms combined with steep slopes result in avalanche danger. Additional factors that contributing to slope stability are amount of snow, rate of accumulation, moisture content, snow crystal types and the wind speed and direction. In Utah, the months of January through April have the highest avalanche risk.

Topography plays a vital role avalanche dynamics. Slope angles between 30 to 45 degrees are optimum for avalanches with 38 degrees being the bulls-eye. Slopes with and angle above 45 degrees continually sluff eliminating large accumulation. The risk of avalanches decreases on slope angles below 30 degrees.

Types of Avalanches Common in Utah

Dry or slab avalanches: occur when a cohesive slab of snow fractures as a unit and slides on top of weaker snow, breaking apart as it slides. Slab avalanches occur when additional weight is added quickly to the snow pack, overloading a buried weaker layer. Dry snow avalanches usually travel between 60-80 miles per hour, reaching this speed within 5 seconds of the fracture, resulting in the deadliest form of snow avalanche.



Wet avalanches: occur when percolating water dissolves the bonds between the snow grains in a pre-existing snow pack, this decrease the strength of the buried weak layer. Strong sun or warm temperatures can melt the snow and create wet avalanches. Wet avalanches usually travel about 20 miles per hour.

Table I-31 Avalanche Fatalities in Utah 1958-2010 by Activity

	Skier	Climber	Snowboarder	Snowmobiler	Recreation	Worker	Resident
1958 Season – Present	36	5	14	12	12	5	1
Past 10 Seasons	7	3	13	10	9	1	1
Past 5 Seasons	3	0	9	3	4	0	0

* Courtesy of the Utah Avalanche Forecast Center, Snow and Avalanches in Utah www.utahavalanchecenter.org 2011.

Hail Storms

Hailstones are large pieces of ice that fall from powerful thunderstorms. Hail forms when strong updrafts within, the convection cell of a cumulonimbus cloud carries water droplets upward causing them to freeze. Once the droplet freezes, it collides with other liquid droplets that freeze on contact. These rise and fall cycles continue until the hailstone becomes too heavy and falls from the cloud.

Table I-32 Hail Storms by cost above $50,000
1964 to 2010
(Not corrected for inflation)

HAZARD BEGIN DATE	COUNTY	INJURIES	FATALITIES	PROPERTY DAMAGE	REMARKS
7/22/1968	Salt Lake	1	1	$50,000.00	Heavy Rain, Hail and Flooding
5/23/1970		35	0	$500,000.00	Wind and Hail
7/17/1985	Sevier	0	0	$50,000.00	Flood/Hail
7/21/1987	Utah	8	0	$500,000.00	Hail
8/4/1991	Salt Lake, Utah	43	0	$50,000.00	Hail
10/5/1994	Salt Lake	0	0	$550,000.00	Hail
7/26/1996	Iron	0	0	$50,000.00	Hail
6/10/1997	Tooele	0	0	Unknown	Hail
6/18/1997	Utah	0	0	Unknown	Hail
8/26/1998	Utah	0	0	$300,000.00	Hail

"Hazards &

Vulnerability Research Institute (2011). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from www.sheldus.org
*Data reflects Hazard Events until 2009.

Tornados

A tornado is a violently rotating column of air extending from a thunderstorm to the ground. Tornados often occur at the edge of an updraft or within the air coming down from a thunderstorm. Tornadoes can have wind speeds of 250 miles per hour or more,

causing a damage zone of 50 miles in length and 1 mile wide. Most tornados have winds less than 112 miles per hour and zones of damage less than 100 feet wide.

Table 1-33 Number of Observed Tornadoes per County by Alphabetical Order

Beaver	4	Iron	5	Sevier	4
Box Elder	9	Juab	1	Summit	0
Cache	4	Kane	0	Tooele	5
Carbon	1	Millard	4	Uintah	5
Daggett	1	Morgan	1	Utah	9
Davis	15	Piute	1	Wasatch	0
Duchesne	4	Rich	3	Washington	2
Emory	8	Salt Lake	15	Wayne	7
Garfield	1	San Juan	0	Weber	6
Grand	5	Sanpete	10	**TOTAL**	**126***

*Three of the above tornadoes were counted twice because they traveled across county borders.
Courtesy of the National Weather Services.

Number of injuries
2 people on July 8, 1989
1 male on August 14, 1968
1 female on April 19, 1970
1 male on April 23, 1990
2 people on June 2, 1993
1 female on May 29, 1996
5 people (or more) on August 20, 1998
80 people (ore more) on August 11, 1999
1 female on September 3, 1999

Number of deaths
1 male on August 11, 1999
1 female was killed on July 6, 1884.

Stated monetary damage by tornadoes:

1,200	June 1, 1955
5,000	June 16, 1955
20,000	June 3, 1963
2,000	August 28, 1964
10,000	April 17, 1966
15,000	November 2, 1967
50,000	August 14, 1968
5,000	May 29, 1987
3,000	May29, 1988
25,000	September 17, 1989
8,000	April 4, 1993
50,000	May 3, 1993

Plastic cup logged in storefront sign as a result of the August 11, 1999 tornado.

15,000	June 2, 1993
500,000	May 29, 1996
170,000,000+	August 11, 1999
100,000+	September 3, 1999
500	March 23, 2000
100,000	May 25, 2000
1,500	September 23, 2002
2,000,000	September 8, 2002
100,000	March 8, 2002
100,000	March 23, 2004
173,011,200+	**Total**

1999 Salt Lake Tornado damage

Utah's strongest Tornadoes

F2	January 22, 1943	Young Ward
F2	June 3, 1963	Bountiful
F2	November 2, 1967	Emery
F2	August 14, 1968	West Weber
F2	May 29, 1987	Lewiston
F3	August 11, 1993	Uinta Mountains
F2	August 11, 1999	Salt Lake City
F2	September 8, 2002	Manti

Waterspout

Waterspouts are simply tornadoes that form over warm water. This typically occurs in Utah during a cold fall or late winter storms.

Location of Waterspouts January 1950 to January 2007

Great Salt Lake	12
Utah Lake	6
Bear Lake	10

Scale

Tornadoes are classified by wind damage using the Fujita Scale. The National Weather Service has used the Fujita Scale since 1973. This scale uses numbers from 0 through 5 with higher numbers assigned based on the amount and type of wind damage.

Table I-34 Fujita Scale

Category F0	Gale tornado (40-72 mph)	Light damage. Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage to sign boards.
Category F1	Moderate tornado (73-112 mph)	Moderate damage. The lowers limit is the beginning of hurricane wind speed; peel surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off roads.
Category F2	Significant tornado (113-157 mph)	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object

		missiles generated.
Category F3	Severe tornado (158-206 mph)	Severe damage. Roofs and some walls torn off well constructed houses; trains overturned; most trees in forest uprooted; cars lifted off ground and thrown.
Category F4	Devastating tornado (207-260 mph)	Devastating damage. Well-constructed houses leveled; structure with weak foundation blown off some distance; cars thrown and large missiles generated.
Category F5	Incredible tornado (261-318 mph)	Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobiles-size missiles fly through the air in excess of 100 yards; trees debarked; incredible phenomena will occur.

Assessing Vulnerability by Jurisdiction

*Requirement §201.4(c)(2)(ii): [The State risk assessment **shall** include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State **shall** describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State owned critical or operated facilities located in the identified hazard areas shall also be addressed … .*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development…

Assessing vulnerability and determining which counties if any are more vulnerable to the hazards grouped as severe weather is very problematic. Using the principle of the past being the key to the future is somewhat useful. For example, Salt Lake County has had the largest number of deaths attributed to lightening, one could assume, that this trend will continue into the future. Yet, this is not a certainty. Know one knows were the next bolt of lightening will strike. Additionally, Salt Lake County contains the states largest population, which has little to do with the higher number of fatalities. San Juan County has the next largest number of fatalities due to lighting and is one of Utah's least populated counties. Just 23 of Utah's 29 counties have experienced a lighting death, 25 of 29 counties have experienced a tornado, and all 29 counties have experienced hailstorms, blizzard, heavy snow, and downbursts.

"Hazards & Vulnerability Research Institute (2011). The Spatial Hazard Events and Losses Database for the United States, Version 5.1 [Online Database]. Columbia, SC: University of South Carolina. Available from www.sheldus.org
*Data reflects Hazard Events until 2009.

Estimating Potential Losses by Jurisdiction

Requirement §201.4(c)(2)(iii): [The State risk assessment shall include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development…

It is virtually impossible to estimate potential losses by jurisdiction for the phenomena grouped into severe weather. Several factors limit determining potential losses they include:

- Lack of research on location
- Most hazards are tied to weather and can not be predicted with a location
- Limited GIS data available for the single map able hazards of avalanche,
- The entire state shares the nearly the same risk

Severe weather hazards can do extensive damage to property and crops, but with the exception of avalanche, can occur at almost any time in any area of the state.

Avalanches typically occur on snow-loaded slopes between 30 and 45 degrees with 38 degrees being the optimum slope angle for avalanches. Avalanches typically do very little property damage as the often occur in forested or alpine areas outside of the human built environment. Yet, numerous residents of the state are still killed each year by avalanches, and the cost of search and rescue or body recovery is burdening county governments, typically tasked with the search and rescue effort.

When considering dollar losses as a function of potential losses and thus jurisdictional vulnerability, a key variable is the value of the human built environment and population. Therefore, the more populous counties along the Wasatch Front would rise to the top, those counties being Salt Lake, Davis, Weber, Tooele, and Utah.

Assessing Vulnerability by State Facilities

Requirement §201.4(c)(2)(ii): [The State risk assessment shall include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State owned critical or operated facilities located in the identified hazard areas shall also be addressed … .

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development…

With the exception of avalanches and tornados, weather-related hazards typically cause very little damage to state owned facilities. The August 1999 tornado in Salt Lake City tracked just east of the state capitol doing extensive damage to several of the state owned buildings in the capitol complex, breaking windows and downing trees. All of the state owned facilities share an equal risk of being struck by a tornado, or having damage done to them by a severe weather. As with most hazards building codes adopted of late, incorporating advances in science and engineering, have resulted in newer buildings being more resistant to the forces of severe weather.

Very few building exist in known avalanche slide paths and extensive research has found no case were a state owned facility was damaged by an avalanche. Avalanches do periodically block mountain roads limiting access to ski resorts and detouring critical transportation routes.

Estimating Potential Losses by State Facilities

Requirement §201.4(c)(2)(iii): [The State risk assessment shall include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development…

As the State of Utah remains vulnerable to severe weather, state-owned facilities are equally at risk to incur damages due to hazard occurrences. However, the state's resources, both monetary and fixed assets, depend heavily upon these facilities and there continuity. As of 2006, Utah has a total of 5,962 state owned facilities with a current value of 14.8 billion dollars. To some extent all of these state owned facilities are vulnerable to severe weather. The extent to which this risk is present has to do with location, construction type, height, and age. Table I-33, is a total of all state owned facilities in each county and their total insured value.

Table I-35 Total Number of State Owned Facilities per County and Their Current Value

County Name	Count Facilities	Insured Value
Beaver	43	$59,658,705
Box Elder	135	$384,071,542
Cache	586	$1,520,883,525
Carbon	135	$208,266,895
Daggett	29	$15,121,339
Davis	352	$1,473,229,390
Duchesne	102	$162,843,693
Emery	111	$111,498,739
Garfield	75	$56,085,456
Grand	79	$49,168,990
Iron	230	$542,074,952
Juab	73	$86,657,955
Kane	71	$59,766,836
Millard	85	$151,693,827
Morgan	67	$71,260,550
Piute	24	$17,118,968
Rich	63	$22,581,600

Salt Lake	2221	$9,243,977,141
San Juan	104	$155,374,819
Sanpete	189	$400,181,595
Sevier	127	$194,770,108
Summit	143	$286,656,757
Tooele	94	$325,264,444
Uintah	131	$232,447,687
Utah	625	$2,874,167,305
Wasatch	156	$178,608,368
Washington	252	$814,071,164
Wayne	36	$17,077,394
Weber	398	$1,595,063,587
OVERALL TOTAL	**6736**	**$21,309,643,331**